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ALLEGHENY FOREST EXPERIMENT STATION

ADDRESS REPLY TO
DIRECTOR
AND REFER TO

UNIVERSITY OF PENNSYLVANIA
3437 WOODLAND AVE.
PHILADELPHIA, PA.

R - AL
Investigative Program

December 11, 1931.

Dear Sir:

Enclosed is a copy of the report of this Station for the year 1930, distribution of which has been unavoidably delayed. You will also find at the end of the 1930 account a statement of our plans to June 30, 1932, and of the Station needs for the future.

We hope that the program of the Allegheny Station will receive your interest and support. Criticisms and suggestions will be most welcome to us.

Very truly yours,

R. D. Forbes,
Director.

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FOREST SERVICE

REPORT OF THE

ALLEGHENY FOREST EXPERIMENT STATION

May 1 to December 31, 1930

PLAN OF WORK

January 1, 1931 to June 30, 1932

and

STATION NEEDS

ALLEGHENY FOREST RESEARCH ADVISORY COUNCIL

1930

Dr. Jacob G. Lipman, Chairman, Director, New Jersey Experiment Station, New Brunswick, New Jersey.

Dr. Rodney H. True, Vice-Chairman, University of Pennsylvania, Philadelphia, Pennsylvania.

R. D. Forbes, Secretary

F. W. Besley, State Forester, Department of Forestry, Baltimore, Maryland.
George W. Butz, Butz Lumber Company, Wilmington, Delaware.
Phillip S. Collins, Vice-President and Treasurer, Curtis Publishing Company, Philadelphia, Pennsylvania.
Professor J. A. Ferguson, Pennsylvania State College, State College, Pennsylvania.
J. S. Illick, State Forester, Department of Forests and Waters, Harrisburg, Pennsylvania.
Dr. O. E. Jennings, Curator of Botany, Carnegie Museum, Pittsburgh, Pennsylvania.
Henry W. Leeds, Chalfonte-Haddon Hall, Atlantic City, New Jersey.
A. J. Musser, General Manager, Clearfield Bituminous Coal Corporation, Indiana, Pennsylvania.
Louis C. Madeira 3d, Madeira Hill & Company, Broad and Spruce Streets, Philadelphia, Pennsylvania.
Edward C. M. Richards, Mt. Carbon, Pottsville, Pennsylvania.
DeCourcy W. Thom, Maryland Trust Building, Baltimore, Maryland.
B. F. Tillson, North Caldwell, New Jersey.
Capt. A. R. Wheeler, Wheeler & Dusenbury Company, Endeavor, Pennsylvania.
C. P. Wilber, State Forester, Department of Conservation and Development, Trenton, New Jersey.

ALLEGHENY FOREST EXPERIMENT STATION

(In cooperation with the University of Pennsylvania)

Philadelphia, Pennsylvania

Permanent Staff

Forest Service

R. D. Forbes, Director
A. B. Hatch, Assistant Silviculturist (reinstated September 1)
A. F. Hough, Assistant Silviculturist
G. Luther Schnur, Assistant Silviculturist
O. M. Wood, Assistant Silviculturist
H. F. Morey, Junior Forester

Miss C. Eunice Skamser, Senior Clerk
Miss Julia Pruitt, Junior Clerk
Miss Hazel V. Loose, Statistical Clerk

Bureau of Plant Industry (Forest Pathology)

L. W. R. Jackson, Assistant Forest Pathologist, in charge
K. D. Doak, Assistant Forest Pathologist

Temporary Assistants

Birger Berg, field
E. S. Cary, field
R. T. Clapp, field
A. L. McComb, field

Miss C. Adelman, office

Allegheny Forest Experiment Station

REPORT FOR THE PERIOD FROM

MAY 1 TO DECEMBER 31, 1930.

by R. D. Forbes, Director.

ADMINISTRATION

The most important event of the eight months has been the beginning of active cooperation between the Bureau of Plant Industry and the Forest Service. An appropriation of $10,000 annually, under the authorization of the McNary-McSweeney Act, has enabled the Bureau of Plant Industry to assign to the Allegheny Station two men from its office of Forest Pathology. Mr. L. W. R. Jackson, who has charge of the work, reported in June, Mr. K. D. Doak arrived in October. Although their work will receive technical direction from the office of Forest Pathology in Washington, their assignment to the Experiment Station is a recognition that unified attack is necessary on all of the problems of forest growth, whether silvicultural, pathological, entomological, zoological, or economic. The station hopes eventually to have men working with it in all of these fields, through the cooperation of other bureaus of the Department of Agriculture, and other offices in the Branch of Research of the Forest Service.

The reinstatement of Mr. A. B. Hatch on September 1 brought the Forest Service staff once more up to its full quota of six technically trained men.

Advisory Council

The meeting of the Advisory Council was held in Philadelphia on May 14. The director of the station presented his report covering the work of the preceding 13 months, and proposed a program of work for the next field season which was largely a continuance of projects already under way. A proposed study of the damage which fires of varying severity do to different forest types, was discussed in some detail, and finally added to the list of projects already approved by the Council. Mr. Munns, Chief of Silvics, Washington, D. C., described briefly the Forest Survey recently undertaken by the Forest Service. State Forester Illick of Pennsylvania outlined the plans of the Pennsylvania Forest Research Institute. The Institute will direct its efforts toward solving the many very practical problems of the State Forests, in the fields of administration, protection, and silviculture. Professor R. C. Hawley, of Yale University, described the management of 20,000 acres of forested land owned by the New Haven Water Company, for which he has been the forester for the past 20 years. Professor L. G. Romell, of Cornell University, spoke on the place of research in the development of forestry in Europe, and by implication the place which forest research might take in American forestry.

Cooperation and public relations

The whole-hearted cooperation of the University of Pennsylvania, evinced from the beginning by its furnishing the Station with comfortable office facilities on its campus, has continued to be manifest in concrete ways. In spite of the crowded condition of McFarlane Hall, the Botany Department has turned over to us an excellent laboratory, working space in the adjacent greenhouse, and to meet the needs of the newly assigned men from the Bureau of Plant Industry, additional office space in one of its annexes on Walnut Street. The University's sympathetic interest in Station work has been repeatedly evident in many less tangible ways, such as the inclusion, through its influence, of forestry as a special subject for the winter on the program of the Botanical Society of Pennsylvania. Other departments of the University have been equally cordial in rendering us effective aid,

The station is gradually making a place for itself in the professional and scientific activities of its region. We have been asked to present an account of our work before such organizations as the Pennsylvania Forestry Association, the Pocono Forestry Association, the Pennsylvania Conservation Council, and the Allegheny Section of the Society of American Foresters. More technical discussions have been given before the Soil Seminar of the New Jersey College of Agriculture, the Research Staff of the Pennsylvania State College, and the Research Institute at Mont Alto. The director has served as vice-chairman of the Allegheny Section of the Society of American Foresters. Profitable contacts have been made with such public-spirited organizations as the Regional Planning Federations of Philadelphia and New York. Our location in the railroad center of Philadelphia has brought us an increasing number of visitors.

The station has been instrumental in obtaining a satisfactory distribution of a bulletin by Mr. S. T. Dana entitled "Timber Growing and Logging Practice in the Northeast". This publication, which covers the states of New Jersey and Pennsylvania as well as the territory of the Northeastern Forest Experiment Station, describes in simple terms the treatment which must be given forest lands if they are to continue in a productive state, and also the measures, so far as known, necessary to obtain full timber crops. Thanks to the cooperation of the Pennsylvania Forestry Association the bulletin has received a rather wide distribution in that state; there has been some distribution in New Jersey also. The director of the Allegheny Station is author of another in the same series, entitled "Timber Growing and Logging and Turpentining Practices in the Southern Pine Region". This bulletin applies to the Coastal Plain region of Maryland and Delaware, and distribution will be sought through the State Foresters of those states.

Branch stations

The station's headquarters forest at Camp Ockanickon, a tract of land leased to us by the county Y. M. C. A.'s of four New Jersey counties, suffered severely in a forest fire early in May. In spite of every effort of the New Jersey authorities, the Y. M. C. A., and our own staff, 104 acres of the tract burned over. The blaze was stubborn and spectacular and because of the advanced season did a great deal of damage. We have the small satisfaction of knowing that we had taken all

reasonable precautions against fire and that in a year conspicuous for its prolonged drouth and the number and severity of forest fires we were not the only sufferers.

The Kane Experimental Forest described in last year's report has been formally established by action of the Forester. We have received a portion of the road funds appropriated by the Federal Government for the relief of unemployment, and expect to spend it in making thoroughly accessible the site selected for the proposed field laboratory and living quarters. Emergency funds for building construction have been requested, with fair prospects of our receiving them. The great need of the Experimental Forest will then be for a resident guard, upon whom we can rely for supervision of cutting operations on an experimental scale throughout the year, and for continuous weather records.

CURRENT RESEARCH

Silvics

The investigative work of the past eight months has been concentrated on four main project groups:

1. Methods of cutting and natural reproduction, Allegheny hardwoods.
2. Natural reproduction in the forests of south Jersey.
3. Growth and yield of the eastern oaks.
4. Forest types, particularly those containing considerable amounts of white pine.

The major portion of the station's field work has been done on the first, second, and fourth of these projects, with only a limited amount on the third project. Two articles covering our share to date in the study of growth and yield of oaks, and one on the even-aged character of the white pine type, as revealed by the distribution of diameters in the ordinary stand, have been completed and will be submitted for publication in technical journals.

Some field work has been done on the study of planting in southern New Jersey. Certain phases of the study of the mycorrhiza of forest trees have been actively undertaken by Mr. Hatch, while still in residence in Sweden; joint work with the Bureau of Plant Industry, through Mr. Doak, the Bureau's new representative on the staff of the station, has been delayed until Mr. Hatch's return to Philadelphia early in January. With two men putting their entire time on this study, the mycorrhiza project will become one of primary importance on the station's program.

There are two other approved projects on the program. Some 1930 burns in south Jersey have been examined in the study of fire damage. Little time has yet been available for computation of the data already obtained in the growth study of loblolly pine. There is every prospect that both of these projects can be actively pursued after July 1. We hope to be able to complete our share of the oak mensuration work by that date and Mr. Schnur will then be able to devote his time to the loblolly pine figures, an office job.

One technical paper, covering an investigation not strictly a part of any project, has been submitted for publication. Another, on natural reproduction of white pine in northeastern Pennsylvania, is undergoing revision. A very large amount of data on tree growth as related to soil type at Camp Ockanickon has been compiled by Mr. Wood and submitted to Mr. L. L. Lee at New Brunswick for incorporation in a joint article by these two men.

The following is a detailed account of current projects, roughly in the order of their importance:

1. Methods of cutting and natural reproduction,

Allegheny hardwoods.

East Tionesta Virgin Area

The big job of the summer has been the examination of a virgin stand on the East Branch of Tionesta Creek south of Ludlow and east of Wetmore on the Allegheny National Forest in Pennsylvania. This area is owned by the Central Pennsylvania Lumber Company and is in the process of being logged.

The tract consists of 3000 or more acres, covered principally by beech and hemlock. Other species found are sugar maple, yellow birch, red maple, black birch, black cherry, ironwood (Ostrya), and striped maple. Fortunately man has not disturbed this area greatly. Oil and gas companies have done some cutting for roads, pipe lines, and well openings, and a selective culling of certain valuable species, notably black cherry, white ash, and tulip poplar has covered portions accessible to a plank road from Sheffield. The latter operation took place about 60 years ago, and owing to the uneven distribution of these species parts of the area have hardly been touched at all, while others have had as many as a dozen trees per acre removed.

Examination of the area took the form of a five to ten per cent valuation cruise of parts of five "lots" (about 250 acres each); that is, compass lines were run at regular intervals in a cardinal direction across these lots, and for a distance of half a chain on each side of the line all trees down to 4 inches in diameter were tallied. Each tree was also tallied as belonging to one of the following height classes: below 15 feet; 15-30 feet; 30-50 feet; 50-70 feet; and 70 feet and above. Dead standing trees and trees recently fallen due to windbreak or windthrow were tallied separately by species and d.b.h. class. Old or recently cut stumps were also tallied separately. The tally for each chain length was kept separate, so that we have a record of the tree growth by one-tenth acres. In the virgin forest proper 604 tenth-acres were thus tallied, and in an adjacent area of second-growth, resulting from a cutting of about 60 years ago, 46 additional tenth-acres were tallied.

Reproduction was studied on a transect 10 links, or 1/10 of a chain, wide along the compass line. The area sampled was thus 1/100 of an acre for each chain of strip. A tally of each species by 1 foot height classes up to 10 feet tall was made. On the reproduction strip trees 1, 2, and 3 inches in d.b.h. and over 10 feet in height were classified by the height classes used for the main stand.

At the end of every second chain the lesser vegetation was recorded on a milacre quadrat, and notes were taken on the upper soil profile horizons. These included depth and decomposition of the humus layer, depth and condition, (such as podsolization), color, texture, etc., of the A and B horizons. Relative elevation, slope, and aspect were recorded and the crown density of the stand estimated. Any evidence bearing on the history of the area such as the presence of windfalls, fire, tree disease, grazing, cutting, porcupine damage, etc., was recorded.

In special studies a substantial volume of data were obtained on taper, bark thickness, height, and age of hemlock, over a wide range of d.b.h. Sections from five hemlock stumps of great age were sent to Dr. A. E. Douglas, the astronomer, for use in climatological studies. Among these was a stump about 560 years of age, previously located by the Pennsylvania State Forest School.

Photographs were taken to illustrate, among other things, the type, individual large trees, windthrow, seedlings on old logs, ground cover, cutting areas and utilization, adjacent second growth, porcupine damage, fungi, and soil profiles.

A preliminary study of these data, coupled with observations made in the field, indicates that the composition of the forest is fairly uniform regardless of local topographic or site differences. Hemlock and beech are the outstanding species. Hemlock is commonly the dominant tree in height and ranks high in basal area or volume. Considering the dominant stand, ie. trees above 10 inches in d.b.h., this species ranks first in total number of trees and in frequency of distribution over the area, followed closely by beech. Of the trees 4 to 10 inches in d.b.h. beech predominates, with hemlock a poor second. The other species are all below 30 per cent in frequency of distribution and poor in per cent of total numbers or basal area. They are found in the dominant height class with hemlock and beech, but ordinarily do not reproduce and survive unless aided by windfall of the existing overstory. Windthrow offers the most promising key to species distribution, and deserves special study in the future. Soil conditions are rather uniform on the area, a podsol profile being commonly found regardless of species present today. No signs of fire were seen on those portions of the area intensively studied.

More intimate knowledge of this tract has only served to confirm our previous strong feeling that it has almost priceless scientific value. It is too much to hope that the entire area of some 2500 or 3000 acres remaining uncut could be purchased from its owner, the Central Pennsylvania Lumber Company, and preserved for study as an example of

what nature, unhampered by the axe and saw of the white man, has been working for thousands of years to produce in the Allegheny territory. The plan followed in last summer's field work, has been to cover first of all those portions which are earliest to be cut, in order that we may secure evidence which six months or twelve months hence will have vanished forever. At the same time we have obtained a generalized knowledge of the tract, and find that one lot of 250 acres is almost ideal as a sample for purchase by the Federal government. The stand of timber is representative, and the lot is the most remote from the transportation facilities of the lumber company.

During the past year impetus has been given to the movement for preservation of natural areas by the Forester's revision of the regulations pertaining to such reserves. If the Service policy is sound of setting aside sample virgin areas already a part of the National Forests for future scientific study, as an aid to the correct management of the land surrounding them, the purchase of suitable areas, where such do not exist within the Forests, seems fully justified. The Reservation Commission's 1929 purchase of 100 acres at Hearts Content, because of its scientific value, sets a precedent, but the small size of present appropriations for purchasing forest land of any kind is a great handicap.

Little Arnot plots

A recount was made during the summer of the reproduction which has so far appeared on the four plots in Little Arnot Creek, three of which were cut over in 1928-30 according to different methods. The probable results of these different methods of cutting should be fairly apparent within a few more years, and a knowledge of what has taken place is expected to be of immediate guidance to the Allegheny National Forest in future timber sales.

Kane Experimental Forest

This area furnishes excellent conditions for the pursuit of methods-of-cutting studies, as soon as the Station funds will permit the employment of a resident superintendent. Our experience with logging and wood-cutting on the Arnot plots points very clearly to the absolute need for someone on the ground at all times to supervise extensive cutting operations. Much administrative work - marking of boundaries, stock taking, etc. - must be done before a real program of research may be begun on this tract.

Extensive surveys

Analysis of the data obtained in the extensive surveys of the beech-birch-maple type in northern Pennsylvania, made in 1929, has been somewhat advanced during the past eight months, but not yet completed, by the Director. Its completion is desirable, if not necessary, before any new work, such as the fire damage study is undertaken. It now appears quite possible that in the data from these surveys, the Little Arnot plots, and the East Tionesta virgin area, the station has ample material for a Government bulletin or circular on the composition of the Allegheny hardwood forest.

2. Natural reproduction, south Jersey.

All of the work on this project was conducted by Mr. Wood at the Camp Ockanickon branch station, and except for a few observations in 1928 has dealt exclusively with chestnut oak.

Seed productivity. The 1930 crop of chestnut oak acorns, observed on 81 numbered and described trees of 1 to 11 inches, d.b.h., was in general much heavier than that of 1929 but not so heavy as the 1928 crop. However, some trees bore good crops in all three years, and many others of comparable size bore almost no crop. This productivity was based upon the count of cups on 20 square feet under the crown of each tree.

Acorn viability related to size of tree. Samples of acorns were collected from trees ranging in diameter from 0.6 inch to 20 inches. These were stored under natural conditions and germination noted during the fall of 1930. Practically all sound acorns germinated. There was no relation between germination and size of tree from which the acorns were collected.

Natural seeding. In the fall of 1928, 1080 empty cups were counted under trees on a 1/25-acre plot, and 189 nuts. In the late spring of 1929 there were 12 resulting seedlings. By the fall of 1929 only 3 of these remained. In the spring of 1930 two of these died back to the ground but sprouted. In September, 1930, one more seedling was dead, apparently from drought. The two survivors represent only 0.19 per cent of the seed produced on the area in 1928.

Artificial seeding, 1928. Most of the seedlings that resulted from 1928 acorns sowed near the cabin survived the winter of 1929-30, but some died back to the ground. In July, 1930, 16 of these seedlings were "trenched" to cut off the roots of competing vegetation. That is, a sharp spade was sunk into the ground at some distance all around them. Total height of these and also untrenched seedlings was measured at this time and again in September, but the trenching had evidently been done too late to affect the season's height growth. The same seedlings will be trenched again in 1931 before growth starts.

Artificial pollination of oak flowers. Nothing was done in 1930 on this phase of the project because a serious fire situation intervened at the time the flowers were developing.

Germination of 1929 acorns. Acorns in lots of 78 each were planted in rodent-proof boxes as follows:

1. 2"-3" deep, covered with leaves; planted radicle down, radicle up, and horizontal.
2. ½"-1" deep, covered with leaves.
3. On the surface, covered with leaves.
4. On the surface - no cover.

These acorns and the resulting seedlings were examined at intervals during 1930. Comparative survival and growth as of September is shown in the table:

Depth of planting	Cover	Position of acorn	Dead					Total surviving	Total planted	Per cent surviving	Mean height inches
			Insect	Drought	Dried radicle	Planting method	All causes				
3"	Leaves	Radicle down	3	1		29	33	9	42	21.2	2.36
3"	Leaves	Radicle up	5	6			11	25	36	69.4	3.07
½"	Leaves	Horizontal	1	4	1		6	72	78	92.3	3.28
None	None	Horizontal			78		78	0	78	0	-
None	Leaves	Horizontal	5	8	33		46	32	78	41.0	3.22
½"	Leaves	Horizontal	5	4	2		11	67	78	85.9	-*
½"	Leaves	Horizontal					4*	74	78	94.8	-*

* Data incomplete

Three of the lots had an equal number of acorns planted without protection from rodents. A single acorn out of the 234 planted germinated. All the other acorns were destroyed within a few days of planting.

Squirrel guards. A squirrel guard was placed on a fourth tree during 1930, and three trees were artificially isolated but not provided with guards. Cup and acorn counts were made under the complete crown of all 7 trees. A careful comparison of the number of acorns falling from one isolated, unguarded tree with the number of cups it produced indicated that squirrels do not gather many acorns while the nuts are still on the tree. Moreover, few cups were noted which had been gnawed in order to release the nut, as would have been the case if the squirrels worked in the tree tops.

3. Growth and yield, eastern oaks.

The Allegheny Station's chief contribution to this study has been Mr. Schnur's investigation of the solid contents of a stacked cord of wood. The chemical wood and pulpwood industries commonly buy their raw material by the cord, without any exact knowledge of how much solid wood is contained in that unit. Analysis of the data obtained from 53 cords of northern hardwoods at Westline, Pennsylvania, has encountered unexpected difficulties. It may be that even this considerable volume of material is not enough to warrant final conclusions, but tentative results should be obtained shortly.

With the help of Dr. G. G. Chambers of the mathematics department of the University of Pennsylvania, Mr. Schnur has been able to discover serious errors in his earlier analysis of these figures; these are due to failure to carry the computations to a sufficient number of decimal places. In the belief that the same failure has resulted in inaccuracies and wrong conclusions by other scientific workers, Schnur has prepared an article for publication on the refinement necessary in multiple correlation calculations.

The ten cords of oak measured at Cornwall-on-the-Hudson in the spring of 1930, in another converting factor study, were evidently not sufficient to give satisfactory results. Mr. Schnur has, however, fairly well established that the personal factor does not materially alter the results obtained in converting factor studies. That is, he found that the stacks obtained by three different individuals from identical sticks of cordwood did not differ measurably, and that the same individual could rick up the same wood three different times and obtain nearly the same size stack. This does not affect the assumption commonly made that careless or intentionally loose piling increases the air space in a cord. It is possible, moreover, that stacks of several cords in size would have revealed differences due to the personal factor.

An article by Mr. Morey on the comparative accuracy of different types of hypsometers, or instruments for measuring tree heights, referred to in last year's report, has been completed and submitted for publication in the Journal of Forestry.

Some work has been done on the preparation of volume tables in mine prop units. More than 10 tons of anthracite coal mine props, obtained from four species in the Pocono Plateau, were weighed and measured volumetrically, and gave the following green weights:

Species	No. of trees	Volume of props cubic feet	Green weight lbs. per cu. ft.
Red maple	45	732	53
Sugar maple	3	103	58
Yellow birch	22	281	59
Black birch	17	282	59
Black cherry	4	64	50

This work was done in cooperation with the Pocono Lake Preserve, Pennsylvania. Schnur has incorporated these figures in a technical note for general distribution. This takes the form of alinement charts showing the weight of mine props of various dimensions of the five species.

For the past two years the Pennsylvania State College has been collecting, unknown to us, data for volume tables in mine prop units, both for the anthracite and bituminous coal mines. The College has generously suggested our collaboration in the analysis and publication of these data, which we have supplemented by a limited amount of information on red maple, obtained last summer with the College's help.

Several brief volume table studies will be made by the Allegheny Station before it brings to a close its connection with the oak volume and yield study. The question often arises whether volume tables prepared in a region-wide study, such as that of the oaks of the eastern United States, can be relied upon for local use. It is of course entirely possible that local differences in the taper of trees, or in their bark thickness, will materially affect tree volumes. The station therefore plans to compare the volumes already obtained from a small number of trees in each of two or three different localities within our territory with the corresponding volumes read from the regional tables. If there is little difference, in spite of local differences of soil and climate, the regional tables may be accepted as they stand; on the other hand, if the differences are great, we will endeavor to work out a satisfactory discount technique.

4. Forest types.

The nine climatological charts prepared by Mr. Morey, presenting the main factors of weather which influence vegetation, have been submitted for publication to the Monthly Weather Review, with a brief explanatory text.

In a proposed publication Mr. Hough reaches the tentative conclusion that most white pine stands in the Allegheny territory, both virgin forest and second-growth, have been essentially even-aged. As described in last year's report, the diameter distribution of a number of stands, with a limited amount of age data for some of them, is the basis for this belief. Some additional field data obtained during 1930 have not yielded the conclusive evidence for or against evenness of age of white pine in the virgin stands that we had expected to obtain, but have in a broad way confirmed the even-aged theory. Stump tallies were made of 17 acres in former virgin white pine in Clearfield County, in a 60-year old cutting where the stumps were particularly numerous. The rotting of the sapwood and superficial charring of most of the stumps detracted from the value of the diameter tally, and heart's rot in addition made impossible anything like an accurate count of the rings on

the stumps. Nevertheless, the diameter distribution strongly resembled that of other plots which were known to be even-aged, and the spread of probable ages was not very great. A seven-acre tally of the magnificent stand of mixed white pine, hemlock, and hardwoods in the Cook Forest in Clarion County also showed for white pine the characteristic diameter distribution of even-aged stands. Direct evidence on age of the Cook Forest white pine is very fragmentary, but indicates that the main stand is about 250 years old, and that a few trees are relicts of a generation 400 years old, or older.

Another substantial contribution to the study of the white pine type has been the collection of a large volume of data on age and height of the virgin white pine and associated species at Hearts Content, Allegheny National Forest. These data, combined with a considerable volume of information obtained on second-growth stands during the summers of 1928 and 1930, will, it is believed, enable us to describe with a considerable degree of accuracy the history of this stand.

The Director has served as chairman of a committee on types of the Allegheny Section, Society of American Foresters, and as member of a committee on types of the entire East, of the parent Society. During the year the Section committee has, by the omission of 3 pure types, succeeded in cutting down to 14 the list of 17 forest types hitherto proposed for the territory.

The Station has gladly accepted a proposal from the New Jersey Agricultural Experiment Station that Mr. Lee of that station collaborate with Mr. Wood in a paper describing correlations between forest type and soil type at Camp Ockanickon. This has required our summarizing, by soil types as shown on Mr. Lee's soil map of the Camp tract, the data on tree growth obtained from 342 one-tenth-acre plots. These include number of trees and basal area for each species; in order to take into account successional relations data for stands of different ages have been kept separate.

5. Planting, south Jersey.

The fire of May 5, 1930, at Camp Ockanickon destroyed 490 of the 3899 pine seedlings planted a few weeks before, and reduced the total acreage planted (mostly inter-planted) by 1.9, or to 14.6 acres.

Wood's two examinations of the remaining 3409 seedlings, the first in late April or early May, the second in September, gave the results shown in the table:

	White pine	Red pine	Pitch Pine	Sh'tlf pine	Jack Pine
Total number of trees planted	495	514	605	1000	795
Total surviving					
First examination, number	485	514	574	590	615
" " , per cent	97.9	100.	94.9	59.0	77.4
Second examination, number	394	454	428	422	464
" " , per cent of original number	79.6	88.3	70.7	42.2	58.4
Second examination, per cent of those alive at 1st examination	81.2	88.3	74.6	71.5	75.4
Trees dead					
First examination, number	10	0	31	410	180
Second examination, number	91	60	146	168	151
Per cent of season's loss					
First examination	10	0	17.5	71.1	54.3
Second examination	90	100	82.5	28.9	45.7

The loss in shortleaf pine is largely due to the fact that the stock was almost dead when planted, having been frosted in the hursery. The loss in Jack pine was due to rabbits which ate the seedlings soon after planting. Drought and the shock of planting accounted for practically all the loss in the other species.

Survival and subsequent growth were linked with the size of the seedling when planted. The largest seedlings made the greatest mean height growth during 1930. The greatest survival per cent was also among those seedlings which were large when planted.

Jack pine made the best height growth during 1930. Pitch, red, white, and shortleaf followed in that order.

As yet there is no correlation apparent between overwood and survival or growth. The same is true as to the effect of ground cover.

About 15 acres of similar ground will be planted to pitch, red, shortleaf, and loblolly pines in 1931.

6. Mycorrhiza of forest trees.

The work of Mr. Hatch has been in three fields. He has been attempting to inoculate red and white pine seedlings, grown in nutrient solutions in sterile glass flasks, with 24 different species of fungi known to form, or suspected of forming, mycorrhiza with these or related tree species. The results of these pure culture experiments were checked by similar inoculations of seedlings grown on decomposed leaves of white pine, pitch pine, red maple, and canoe birch. As a third line of investigation Hatch collaborated with another investigator in studies of the behavior of mycorrhizal fungi on seedlings of white, red, and Scotch pines grown under different light intensities.

Previous to reporting at headquarters Mr. Doak made a preliminary survey of mycorrhiza at Ann Arbor, Michigan; Wooster, Ohio; Washington, D. C., and College Park, Maryland. Another collection was made in the Camp Ockanickon, New Jersey, area. All of these were studied in detail microscopically and permanent preparations made for comparison with mycorrhiza produced later in synthesis experiments. Estimates of the amount and kind of mycorrhiza or pseudomycorrhiza were made at these locations and some records of root conditions at different depths obtained. Mycorrhizas were found on each species collected in natural stands and a plantation at Ann Arbor, Michigan. Pinus strobus, P. taeda and P. echinata collected in the College Park, Maryland nursery showed mostly well-developed mycorrhiza with only occasional pseudomycorrhiza. At this season, a large proportion of the mycorrhiza formed during the summer months were dead and dark brown in color. It was possible, even in this condition, to distinguish them microscopically as well-formed ectotrophic mycorrhiza.

7. Fire damage

At Camp Ockanickon 5 semi-permanent plots were established following the 1930 spring fire. Two more were established on the Lebanon State Forest, and four on the Bass River State Forest. The eleven plots were selected to give a good representation of the species and age classes typical of the Coastal Plain forests. Each tree was numbered, and its diameter and the following data as to damage were recorded: height of scorching, circumference scorched, estimated condition (dead, severe, medium, or light injury), and presence and position of sprouts. The height of sample trees on each plot was measured.

Some tabulation of these data has been made. However, final results of the fire will not be apparent until the plots have been reexamined in 1931.

A very brief reconnaissance has been made of Catoctin Mountain in central Maryland, where it had been proposed to begin field work on this study in 1931, and the fire maps for the mountain were examined and discussed with the Maryland authorities.

8. Growth and yield, loblolly pine.

The only progress which it has been possible to make in this study during the current year has been the transfer of some of the field data to office forms.

Forest pathology*

During the period from June 16 to December 31, 1930, the work at the Philadelphia branch office of Forest Pathology, cooperating with the Allegheny Forest Experiment Station, may be summarized as follows:

1. Organizing and equipping new laboratory and office facilities.
2. Investigating the more important forest tree diseases prevalent in the Allegheny region.
3. Organization of new research projects on forest tree diseases in the Allegheny region.
4. Preparation of publications.
5. Initiation of the mycorrhiza study by Mr. Doak.
6. Cooperative work with the Allegheny Forest Experiment Station, with the University of Pennsylvania, particularly through Dr. True of the Botany Department, and with the various state agencies within the region.

New laboratory space was granted the Forest Service and Bureau of Plant Industry in the MacFarlane Hall of Botany. Additional space has been given to Forest Pathology on the third floor of Botany Annex No. 4 at 3436 Walnut Street. The front room, which has been equipped with furniture and filing cases, will serve as office quarters for Doak and Jackson. The remaining space will be used for storage, especially pathological collections. The stenographic work has been greatly facilitated by the installation of an Ediphone, since the Forest Service has Dictaphone service.

According to present arrangements the investigative work is divided into two major groups, namely: (1) General forest tree diseases and (2) mycorrhiza of forest trees.

1. General Forest Tree Diseases.

At present the following projects, under general forest tree diseases, have been proposed for investigation in this region:

1. A study of the heartrots in the sprout hardwoods.
2. A study of damping-off and rootlet rot diseases of coniferous seedlings in forest nurseries.
3. Disease survey for the Allegheny region.

*Report prepared by Mr. Jackson.

Project 1.

Object: To study the entrance of decay in hardwood sprouts, particularly oak, through causes independent of fire injury.

Field results: The first work on this project must consist necessarily of a survey for the purpose of locating sprout stands without any fire history. In order to expedite the location of these areas we shall have to depend to a large extent on cooperation from various outside agencies. State Forester Besley of Maryland has expressed his interest in the problem by submitting a list of about 40 cutting operations, representing a period of several years, where the stands were chiefly oak. Mr. Krell, forester for the Pennsylvania Railroad, has given us what information they have available concerning cutting operations in Pennsylvania. State Forester Wilber of New Jersey has assured us of his cooperation in locating areas in New Jersey. Mr. Tillson believes there are several fire-free areas throughout northern Jersey.

During the fall of 1930 a preliminary study was made of the Camp Ockanickon area. Several heartrot specimens were collected. The predominating heartrots, as evinced by sporophores, seemed to be Hydnum erinaceus and Fomes everhartii. Several cultures and photographs were obtained.

Project 2.

Object: To determine the effect of hydrogen-ions (pH) and aluminum-ions on the incidence of damping-off diseases of coniferous seedlings in artificial cultures.

Coniferous seedlings are grown and inoculated in nutrient solution cultures with varying pH values. So far two experiments have been completed, using a modified Shive solution with two different hosts against two different strains of damping-off organisms, namely, Pythium sp. and Rhizoctonia sp. At present studies are being conducted to find a nutrient solution which will remain stable throughout the high pH points i.e., pH 6.5-8.0 and at the same time supply in available forms all the essential nutrient elements.

Cooperative work with forest nurseries:

The cooperative work will consist chiefly in keeping in touch with the various forest nurserymen and suggesting recommendations for the control of seedbed diseases prevailing in their respective nurseries. During the past year recommendations have been given to the Monongahela Nursery at Parsons, West Virginia, and the Delaware State Nursery at Milford, Delaware. During the course of summer field trips visits were made at the New Jersey State Nursery, Washington's Crossing, New Jersey, Maryland State Nursery at College Park, Maryland, and the Greenwood Furnace and Clearfield Nurseries of Pennsylvania.

II. Mycorrhiza of Forest Trees.

See previous statement under same heading, "Silvics", page 13.

PLAN OF WORK

January 1, 1931 to June 30, 1932.

Silvics

Since the establishment of the Station in 1927 eight lines of work have been approved. In terms of men employed and funds expended on them during 1930 these projects may be classified as follows:

Major projects, 1930.

Methods of cutting and natural reproduction, Allegheny hardwoods.
Natural reproduction, south Jersey.
Growth and yield, Eastern oaks.
Forest types.

Minor projects, 1930.

Planting, south Jersey.
Mycorrhiza of forest trees.
Growth of loblolly pine.
Fire damage.

Cooperation of the Office of Forest Pathology, Bureau of Plant Industry, and the reinstatement of Mr. Hatch, now make possible to begin a two-man attack on the very important and difficult study of forest mycorrhiza.

Completion of our share of the oak growth study by June 30, 1931, will release Mr. Schnur for the loblolly pine growth project, based on the oldest sample plots of the Forest Service - established in 1904 on the Eastern Shore of Maryland. The forest type studies, it is hoped, can be advanced sufficiently by Mr. Forbes during the first six months of 1931 to make possible their relegation to the "minor" classification. The remaining two projects in the "major" group will, however, increase rather than diminish in importance. Greater emphasis on the study of natural reproduction of Allegheny hardwoods will result from the establishment and development of the Kane Experimental Forest. This project will absorb all of Mr. Hough's time, part of Mr. Morey's, and the lion's share of our temporary assistants'. The natural reproduction study in south Jersey will fully occupy Mr. Wood, except for a few weeks on the planting study, and should be intensified if possible by the employment of skilled temporary assistance.

To sum up, proper continuance of projects already begun, and the expansion of the mycorrhiza project, will make such demands on the technical staff of six men that development of any new work, even though approved, is out of the question. Specifically, this means that the fire damage project, important though it is, must be postponed, except for the very small amount of work involved in re-examination for a year or two of the south Jersey plots. The Director had hoped that with the virtual completion of current phases of the type study he would be available for leadership in the fire project. But increasing age and size of the Station have so multiplied the contacts which must be maintained and enlarged with individuals and organizations in our territory, and have so expanded the other administrative duties of the Director, that a few weeks in the field is all he could hope to give. The critically important office analysis would have to be turned over to another - a very poor practise, even if an experienced man were available to undertake it. The decision to hold up development of this project is a disappointment to the Station, but is necessitated by the need to concentrate on going projects if any progress at all is to be made.

The work of the Station during 1931 will then be grouped as follows:

Major projects, 1931-2

Methods of cutting and natural reproduction, Allegheny hardwoods.
Mycorrhiza of forest trees.
Natural reproduction, south Jersey.
Growth of loblolly pine.

Minor projects, 1931-2

Planting, south Jersey.
Forest types.
Fire damage.

Additional details as to the work planned in each project appear below:

Method of cutting and natural reproduction, Allegheny hardwoods. Only final analysis of the data for the East Tionesta tract will show how much more work is immediately necessary in this virgin timber, but it is hoped that it will be little, and that after its completion a real start can be made in 1931 toward surveying, cruising, and otherwise developing the Kane Experimental Forest. Supervision of the building construction there may make unexpected demands on Mr. Hough's time before June 30, 1931, and seriously interfere with office work.

Mycorrhiza of forest trees. Major emphasis during the coming field season at least will be placed on a field survey of the Allegheny territory, to determine the amount of mycorrhiza formation on the most important tree species of the region, both in nurseries and under natural conditions; and to collect and identify as rapidly as possible the fungi responsible for mycorrhiza formation. Laboratory work will be confined to culturing, for ultimate identification, the principal mycorrhiza-forming fungi, and to development of methods for sterile flask culture of tree seedlings. For a more detailed statement see the same heading under "Forest Pathology" below.

Natural reproduction, south Jersey. The work will be intensified by giving Mr. Wood his full time on the project, except for the minor amount necessary to care for the planting project in the same territory. The objective will be increasingly fundamental work, of necessity concerned more with individual trees or small groups than with extensive stands, and therefore well adapted to conditions at Camp Ockanickon. Such work also seems to offer the greatest opportunity for cooperation with the Botany Department of the University of Pennsylvania. Soil moisture, as a promising key to seedling survival, will be chiefly studied.

Growth of the eastern oaks and of loblolly pine. The Station, through Mr. Schnur, will cooperate with the Pennsylvania State College in the preparation of a bulletin on volume tables in terms of mine props. The sample plot data for loblolly pine will be analyzed in several ways, chiefly as a check on the existing yield tables for this species. Some information on thinnings will also be obtained.

Forest types. Fresh evidence obtained in Clearfield and Clarion counties, of the even-aged character of virgin white pine will be incorporated in Mr. Hough's paper on this species. Mr. Morey will prepare a paper on the history of the virgin forest at Hearts Content, as revealed in his study of age and height relationships. It is hoped that the data from the 1929 extensive survey of the beech-birch-maple type in northern Pennsylvania will yield sufficient information, when combined with other data already on file concerning this type, to justify a Departmental circular, prepared jointly by Mr. Forbes and Mr. Hough.

Planting, south Jersey. Four or five species of pine will be planted in the openings among the sprout hardwoods on about 20 additional acres at Camp Ockanickon. The 1930 plantations will be reexamined twice a year, and fail places replanted in the spring. The number of planted seedlings under observation by the end of the 1931 planting season will be about 5,000.

Fire damage. Mr. Wood will repeat his observations of the 11 temporary plots in fire-damaged stands laid out following the fires of 1930 in southern New Jersey.

Forest Pathology.

1. General forest tree diseases.

In the study of heart rots in sprout hardwoods the chief work of the 1931 field season will be to select a number of recently cut-over, fire-free stands throughout the region, and to establish in them temporary sample plots. Stump measurements and dissections will be made to establish the relationships between repeated coppicing and decay.

After the study of the effect of pH on damping-off diseases has been satisfactorily completed, work will be extended to include the effect of the aluminum-ion. Ultimately the rootlet rot will be investigated. Cooperation with forest nurseries in the investigation of their own damping-off problems will be continued.

The disease survey will also be continued.

II. Mycorrhiza of forest trees.*

The following projects have been proposed for study of forest tree mycorrhizas in the Allegheny region:

1. Survey of mycorrhizas occurring in nurseries, plantings and stands in the Allegheny region.
2. Effect of mycorrhiza on the growth of seedlings under controlled conditions.
3. Effect of moisture on the production and action of mycorrhizas under controlled conditions.
4. Fungi producing mycorrhizas on introduced chestnuts.

Project 1:

Object: To investigate the occurrence of mycorrhizas in the Allegheny region and to obtain information from the field in the following respects:

a. Amount of development on species in pure stands and mixed stands.
b. Amount of development in plantings.
c. Amount of development in nurseries.
   (a.) Effect of location and handling on development.
d. Effect of soil type and humus cover type on amount of mycorrhiza.
e. Effect of fire on development.
f. Effect of the presence of other root diseases in stands, nurseries and plantings on amount and condition of mycorrhiza, and the effect of mycorrhiza on root diseases.
g. Effect of soil moisture on mycorrhiza development.
h. Collection of material from all above conditions for critical investigation of root conditions and isolation of the fungi producing them.

* Report by Mr. Doak.

Discussion:

It has been proposed that areas representing typical forest conditions be selected for this investigation. Recording of the occurrence of ectotrophic and endotrophic forms will be accompanied by systematic collections of mycorrhizas and the fungi producing them whenever possible. Investigation of the occurrence of mycorrhizas will include the following:

a. Amount of roots showing developed as mycorrhizas.
b. Distribution of mycorrhizas relative to depth in the soil and position on root system.
c. Time of development of mycorrhizas and persistence of both root and fungus in a living condition. This would involve seasonal records of mycorrhiza formation in selected locations.

This survey will be conducted during the period of mycorrhiza formation at intervals beginning about April 1 and continuing until about November 1. Collection of material from the field and isolations made would aid in obtaining a collection of authentic cultures for identification purposes and use in later work. It is proposed that this survey will be started as soon as possible in 1931 and be continued as a long period study each year.

Project 2:

Object: To investigate the effect of mycorrhizas on the growth of seedlings under controlled conditions.

Discussion: Due to the difficulties encountered in conducting such investigations under sterile and controlled conditions for long periods of time, it is proposed that various methods will be given trials. At the present time facilities are being arranged for making such trials.

Project 3:

Object: To investigate the effect of moisture on development of mycorrhizas on seedlings under controlled conditions.

Discussion: It is proposed to use methods developed for use in project 2 for making this investigation.

Project 4:

Object: To investigate the fungi producing mycorrhizas on introduced chestnuts.

Results: Isolations have been made from roots of chestnut seedlings sent from Washington, D. C., and from sporophores found in connection with the mycorrhizas. The same fungus was obtained from both sources. In determining its growth on various kinds of media, 2.5 per cent malt in 2 per cent agar was found most favorable. All roots examined showed ectotrophic mycorrhizas with loose mantles. Apparently the same fungus produces them since the mantle characters were identical in all material examined.

ESTIMATED EXPENDITURES, FISCAL YEAR 1932.

Estimated costs of the several lines of work for the fiscal year 1932 (July 1, 1931 to June 30, 1932) are as follows:

Silvics

1.	Methods of cutting, Allegheny hardwoods	$11,000
2.	Mycorrhiza of forest trees	7,200
3.	Natural reproduction, south Jersey	5,000
4.	Growth of loblolly pine	5,000
5.	Forest types	2,000
6.	Planting, south Jersey	1,000
7.	Fire damage	320
	Total	$31,520

Forest Pathology

1.	Oak rots and damping-off diseases	$ 5,000
2.	Mycorrhiza of forest trees	5,000
	Total	$10,000

STATION NEEDS

1. A study of the influence of forests and other vegetation on stream flow for domestic and commercial use.

The great drought of 1930, which seriously reduced the water supply of nearly every city in the East, subjecting city dwellers to inconvenience, to grave danger from uncontrollable fires, and in a few instances to threats of epidemics, has brought suddenly to the fore the serious problem of how to provide constant municipal water supplies for domestic and industrial use. It has removed the relationship of forests and other vegetation to the flow of streams out of the category of academic speculations, and placed it squarely in the realm of the practical. An adequate program of Federal forest research in the Allegheny Region should most emphatically include a study of this relationship.

A striking characteristic of the Allegheny territory is the extremely high concentration of population around metropolitan centers, such as New York, Philadelphia, Baltimore, and Pittsburgh. Over 40 per cent of the population of Pennsylvania, New Jersey, Delaware, and Maryland are concentrated about the first three of these cities. The Regional Planning Federation of the Philadelphia Tri-State District estimates that Bucks, Chester, Delaware, Montgomery, and Philadelphia Counties in Pennsylvania; Burlington, Camden, Gloucester, Mercer, and Salem Counties in New Jersey; and New Castle County in Delaware contained in 1927 a population of 3,530,000, which will increase to 6,466,000 by 1980. Bergen, Essex, Hudson, Passaic, and Union Counties, New Jersey, which are included in the territory covered by what is known as the Regional Plan of New York and its Environs, today contain a population of approximately 2,000,000, which according to the Plan will be more than doubled by 1965. Baltimore's 1927 population was 819,000, and is growing at similar rates.

The task of supplying water for domestic use to a population concentrated in a relatively small area is a stupendous one. Yet it may even be overshadowed by that of supplying water for industrial purposes; thus in 1920 the Water Supply Commission of Pennsylvania reported that of a total consumption of 442 million gallons daily by the lower Delaware Basin 246 were used industrially. The Regional Planning Federation of Philadelphia, in a preliminary and tentative report not yet approved for publication, estimates the present consumption of water in its territory at 467 Mgd.* and that of 50 years hence at 800 Mgd. According to the Water Policy Commission of New Jersey the "Northern Metropolitan District" of that state, which coincides pretty well with the portion of New Jersey included in the Regional Plan of New York and its Environs, now uses 275 Mgd. and 10 to 30 years hence will require from 150 Mgd. more. At a per capita rate of 132 gallons daily (the Philadelphia figure), Baltimore's water use must be nearly 110 Mgd.

Ninety-two per cent of the Philadelphia Region water, and probably a similar very high percentage of the present north Jersey and Baltimore supplies, comes from surface waters - large or small streams. It does not seem either desirable or feasible to rely on the large streams of the region, such as the Delaware and Schuylkill for the additional supplies urgently needed. Pollution is often serious, even where volume is adequate. The Regional Planning Federation of Philadelphia states in the report already referred to: "It is doubtful if there is a river of similar size in the United States, undeveloped by storage, which is utilized more intensively and completely for water supply than the Schuylkill". Philadelphia proper can continue to draw from the Delaware, only one-fifth of the volume of which is now used, but the needs of the surrounding district can be hardly so supplied, in part owing to the necessary expense of raising the water to high levels by pumping. The New Jersey authorities apparently do not even consider the Hudson or upper Delaware as a source of future supplies, but insist on the need for "high level" development.

*Mgd. = million gallons daily.

Underground waters are not an alternative source of future water. The Regional Planning Federation says of this source of supply around Philadelphia: "Out of a total of 37,000,000 gallons daily from underground sources, 33,000,000 gallons are drawn from wells in New Jersey, mostly in Camden and Gloucester Counties. These wells range in depth from 35 to 660 feet, and generally may be said to draw water from the same strata - the Raritan formation --- The draft on this formation is growing yearly at a rate of about 3 per cent --- There is already an apparent definite lowering of the water bearing level". It must of course be remembered in connection with deep wells that after all the water in them is only surface water precipitated at some distant point. "The Raritan formation --- is apparently fed by seepage from the rainfall and water courses, on a strip of territory about ten miles wide, running from Trenton to Pennsgrove and including the Delaware River". The deep wells of Atlantic City are filled by rain which fell near Medford, New Jersey, 40 miles to the northwest.

It is from the distant head waters of major streams, or from smaller nearby streams, that authorities agree such populous areas as northern New Jersey, Baltimore, and the suburbs of Philadelphia must draw future supplies. An idea of the magnitude of the engineering works required to supply even fairly immediate needs may be gained from the fact that the Water Policy Commission of New Jersey plans a high-level development for northern New Jersey costing from $42,000,000 to $46,000,000, exclusive of conduits to the communities served. Even this gigantic project will not meet needs beyond 1960. The State has already bonded itself in the sum of $7,000,000 to purchase reservoir sites for this development. Baltimore has recently completed an expensive development of the Gunpowder River, and is already obliged to look further ahead. A $30,000,000 development on the Patapsco River will have to be undertaken within 10 years.

It is almost incredible that expenditures running into the millions of dollars have been made, and apparently continue to be made, without those responsible having definite knowledge of how far the vegetation on the watersheds concerned may influence the flow of streams from them. All estimates of the storage facilities - reservoirs behind artificial dams - necessary to supply given amounts of water are based entirely on the behavior of the streams in the past. Yet, to quote the Special Report 1 of the New Jersey State Water Policy Commission, "The relation between the precipitation and surface run-off in the stream varies widely with different conditions of topography, character of soil and underlying strata, <u>forest cover</u>, <u>vegetation</u>, temperature, wind movement, distribution of rainfall, etc."

"Direct measurement of the run-off is the only satisfactory way of determining its amount," says the Commission, which is of course all right as far as it goes. But who can say that a change in the relative proportion of open land and forest within the watershed of the proposed north Jersey development may not so augment the streamflow, or equalize

it as between months, that instead of $42,000,000, $35,000,000 will do? Present ratios of woodland to total area in the region referred to run all the way from 1 to 5 to 5 to 5, on different portions of the watersheds concerned. Forest composition is very diverse. Yet the preliminary report on water supplies, previously referred to, of the Regional Planning Federation of Philadelphia cites one Hope Holway to the effect that a fir or pine forest transpires 4 inches of rainfall annually, a maple forest 8 inches, wheat or grain 10 to 15 inches, and grass 30 to 40 inches. The water thus transpired, it should be realized, reaches no stream, and contributes nothing to a reservoir. On the other hand, Professor R. C. Hawley of Yale, who for twenty years has been forester for the New Haven Water Company, stated in an address before the Allegheny Forest Research Advisory Council, in 1930, that "the net amount of water obtained from a forested watershed in the way of stream run-off is not much different from that secured from an open watershed such as meadow or cultivated land". That such conflicting statements can be made is certain proof that anything like exact evidence is not at hand. Yet it seems to be accepted rather generally by the water companies of the East that forest cover is more efficient than any other type of cover in conserving rainfall and equalizing run-off, since few large companies fail to plant trees on such open or farm land as they acquire on their watersheds. Professor Hawley gives the following reasons, among others, for forestry rather than agricultural development on the watersheds of public water companies: "one to twenty-five per cent more precipitation over forested than over open areas, reduced surface run-off, slower melting of snow in the spring of the year, and lessened erosion."

The dangers of erosion from a deforested watershed (in this instance a farming country) in Maryland was described as follows in "The Forests of Maryland", published by the State Board of Forestry as long ago as 1916; "Between Relay and Alberton, a distance of 11.4 miles, there are 10 water power developments, 8 of which are now in operation. The power for these plants is furnished by the Patapsco River, and its value for that purpose is measured by the evenness of flow and freedom from silt. A forest cover is essential to maximum efficiency in regulating flow, and in preventing erosion with its deposits of sediment. The steep slopes along the river that have been cultivated in years past have largely contributed to the accumulation of silt which has collected behind the dams built for storage purposes and has clogged the river channels, increasing the frequency of floods, and carrying immense quantities of silt into the upper Patapsco near Baltimore, requiring the expenditure of large sums of money for dredging. A very informing illustration of the silt accumulation is shown by the accompanying cut, taken from a photograph along the Patapsco River in front of a dam that had been in use but ten years. This mass of sediment, extending for a quarter of a mile along the river bed, represents but a small part of the surface erosion from cultivated lands along the steep banks of the Patapsco in ten years' time.

The only remedy is to get these steep hillsides under a forest cover as quickly as possible, which is one of the objects of the State in acquiring the lands now in the Patapsco Reserve."

Definite information as to which species of the very large number often available for use in the eastern United States is capable of furnishing the best protection to the watersheds, and at the same time appropriates the minimum amount of moisture for its own use, is certainly almost wholly lacking. Although stating that the pines rather than the spruces should be favored for planting, "as they use less water", Hawley frankly says that "the last word has not been said on the best species for planting". Only a thorough-going study of the transpiration rates of various native species in the Allegheny territory, and of the introduced species which are commonly planted, can furnish highly necessary information on their qualities as cover for municipal watersheds. Certainly no less important is a study of the character of the humus which these species produce. Lowdermilk's finding that muddy water seals the surface pores and very promptly prevents percolation of rainfall into a soil certainly emphasize the need for more knowledge of the ability of the surface layer of humus to deliver clear water to the soil beneath. Absorption of rainfall by the humus layer may tend to prevent too rapid run-off. Hawley says that the "absorption capacity of broad-leaf forest floor is perhaps less than coniferous, but has not been studied yet to state the degree". Whatever may have been done in investigating these matters in Europe, the concrete information available in America, without our great variety of species, is extremely slight.

Once it has been decided what species of trees are most effective as cover for a watershed, there remains a host of problems connected with the management of the forests they compose. Hawley advocates all-aged stands, because wind movement is reduced to a minimum where there are small trees standing among the large; this reduces evaporation. He also advocates mixtures of broad leaved and coniferous species, saying "such a forest possesses to the highest degree ability to maintain the soil in sponge-like condition". Inasmuch as conifers are nearly lacking in the forests of the metropolitan portion of the Allegheny territory, and even-aged rather than all-aged stands are the almost invariable rule, it is very evident that a large amount of investigative work must be done before ideal forests on watersheds can be established and maintained.

One thing appears certain. The influence of vegetation, particularly evergreen vegetation, will be felt throughout almost the entire year. The following table shows that rainfall at Newark, New Jersey, Philadelphia, and Baltimore, is remarkably evenly distributed over the months of the year:

Mean Monthly Precipitation

Month	Newark: 1843-1920	Phila-del-phia: 1872-1920	Balti-more: 1871-1920	Month	Newark: 1843-1920	Phila-del-phia: 1872-1920	Balti-more: 1871-1920
January	3.76	3.27	3.33	July	4.81	4.24	4.66
February	3.62	3.31	3.33	August	5.07	4.74	4.53
March	3.87	3.48	3.74	September	3.76	3.33	3.63
April	3.74	3.16	3.36	October	3.87	2.94	2.82
May	3.97	3.33	3.45	November	3.47	2.99	2.71
June	3.76	3.31	3.87	December	3.88	3.33	3.25
				Annual	47.58	41.43	42.68

The possibility that the establishment and maintenance of proper forest cover on public watersheds can so equalize the monthly flow that large-scale storage facilities will be unnecessary, seems far greater in the Allegheny territory than in regions where rainfall is concentrated during short periods of the year.

To sum up: more than 40 per cent of the population of the Allegheny territory is concentrated in three metropolitan areas, creating a serious problem with regard to water supplies for domestic and industrial use. The solution of this problem, involving the expenditure of many millions of dollars, can not be economically arrived at with our present knowledge of the role which vegetation, and particularly forest vegetation, may play on the regulation of streamflow and the prevention of erosion. Our present almost complete lack of knowledge can be remedied only by research covering a period of at least a decade, if not several decades. It is certainly high-time that such an investigation got under way.

An adequate attack on all of the problems involved in the study outlined above will require the services of at least four men, each trained in a particular specialty. In charge of the project should be a forester of long experience in management of eastern forests, with unusual vision and organizing ability to knit the work of his assistants into a harmonious whole. If at all possible, he should be a man who has had special training in the study of forest influences. As assistants, the man in charge should have a plant physiologist, a soils specialist, and an hydraulic engineer and meteorologist. The problems of transpiration and water use by different species of trees can hardly be solved by anyone short of a trained plant physiologist. A soils specialist is indispensable in any study of rates of percolation, run-off, and similar matters connected intimately with the character of the soil. An hydraulic engineer with an abundant knowledge of meteorology is necessary if measurements are to be made of streamflow.

The regular technical staff should have at times some technical help from less experienced men, and the project should be particularly generously supplied with funds for equipment. Meteorological instruments, dams, weirs, etc., are by no means inexpensive.

The sum of $35,000 annually is believed to be a reasonable estimate of the cost of such a project. Cooperation, and limited financial assistance, as for example in the purchase of equipment and the establishment of permanent improvements for the measurement of streamflow, should be sought from the municipal areas studied.

2. A Study of Fire Damage.

Adequate funds for the prosecution of the fire damage study are imperative, unless the Station is to ignore one of its more important problems. Fires are the greatest hazard to which the business of timber-growing is subject. Although the protection of no forest property against fire can be placed on a business basis unless the damage the property may suffer has been accurately appraised, exact and comprehensive data are not yet available covering the damage done by fire to tree growth of various types and ages, under even the commoner conditions of burning. Still less is known of the damage to productivity of the soil, to the value of the forest as a preventive of erosion, regulator of streamflow, and contributor to recreational values in the form of hunting, fishing, and aesthetic enjoyment. The present annual expenditure in the Allegheny territory of an average of two cents an acre for fire protection may be too great if the damage, as estimated for their state in 1929 by the Pennsylvania authorities, is $2.49 per acre burned; it may be too small if the damage as estimated for their state in the same year by the New Jersey authorities, is $12.29 per acre; or it may be just right if the damage to the particular lands burned over in that year varied with the forest type, and therefore from state to state, by 400 per cent, as these two estimates would imply. But the state authorities themselves bear testimony that their statistics of fire damage are frank guesses, and that often the heaviest protective expenditures per acre are made on lands with the least values in timber. The Federal Forest Service allocates $50,000 yearly to the States of the Allegheny territory for cooperative work in fire protection, without any certain knowledge of the values at stake. Courts award damages for burning of forest land on an equally flimsy basis. The need to determine possible fire damage to the various forest types of the Allegheny region is apparent.

Adequately financed, the study should endeavor to determine, by forest types, the effect of single or repeated fires on the forest at various ages, including killing, stunting, and wounding of the trees; on the chemical, physical, and biological conditions of forest soils, as they influence tree growth, run-off of rainfall, and erosion; and on game, fish, and the attractiveness of the locality to the human race. Such investigations will require the services of two foresters and a soil scientist, with commensurate clerical and temporary assistance. Cooperation in locating of areas suitable for study, reconstructing fire history, and possibly in actual field examinations, will be obtainable from all of the state forestry departments.

This project has been on the Station program for two years, but for reasons earlier stated men and funds could not be spared from earlier projects to undertake it. It should certainly be added to the program at the earliest practicable date. Among the Station's needs it stands second only to the streamflow project.

3. Other Station Needs.

No forest experiment station serving a territory in which there are 18,000,000 acres of forest lands, diverse in character and subject to diverse economic conditions, can discharge its full obligation without including on its staff men trained in forest economics, forest zoology, and forest entomology.

Chief among a multitude of regional economic problems to which the Experiment Station should address itself is that of determining proper methods for appraising the money value of the forest for recreational purposes. Of late years the concentration of population in metropolitan areas has, among other factors, given an enormous impetus to out-of-door recreation; good roads have made relatively accessible to campers, vacationists, hunters, and fishermen by the thousands, localities that a few decades ago were known only to a sparse permanent population. This has been particularly true of the Allegheny territory, where rapid acquisition of borders of lakes and streams for summer homes and of great areas of "wild land" for hunting and fishing preserves has led to a strong movement to buy parks, camp sites, and game lands for public use. Most of these lands, both public and private, are forested, and in many localities the value of the wood and other tangible products on them is completely overshadowed by their less tangible values for recreation. These circumstances have created a need for sound methods of appraising recreational values of the forest, as a basis for policies of land use; for expenditure of public and private funds in protection against fire, insects, and disease; for determining damage by these agencies; and for assessing forest land for purposes of taxation.

A study of recreational values of the forest would compare, for forested and denuded localities of like accessibility, topography, etc., the prices paid for hunting and fishing privileges, for lease of camp and similar part-time residential sites, and for other recreational purposes; also, the local prosperity and wealth created by the presence of recreationists; all as a basis for assigning definite money values to the so-called intangibles of recreational use. This study will require the services of two yearlong men trained in economics, with part-time clerical assistance and abundant funds for travel. The entire project will cost $10,000 annually. Cooperation with state forestry departments and private individuals will be sought.

The influence of animal life upon the forests is being constantly revealed in the Allegheny territory. The most striking illustration so far uncovered is the nearly complete destruction, by rodents and possibly other animals and birds, of successive acorn crops at Camp Ockanickon, in southern New Jersey. Rodent damage at Camp Ockanickon, however, does not stop with the destruction of the seed, but includes serious injury or killing of seedlings which have been raised in protected nurseries and later out-planted. Although not cited as proof that the Station should undertake a study of the subject, which is already under investigation by the state authorities of Pennsylvania, damage to forest growth by deer may be cited as another illustration of the critical relation between the forest and the animals which it harbors. The forest on thousands of acres in Pennsylvania is doomed to ultimate extinction if deer continue to graze the young growth, - the forests of tomorrow - as severely as they do today in parts of the State. One or more forest zoologists are certainly needed on the staff of the Allegheny Station, and the cooperation of the Biological Survey of the Department of Agriculture should be sought to this end.

For similar reasons, the Station greatly needs the services of forest entomologists, from the Federal Bureau of Entomology. Damage by forest insects in the Allegheny territory has never been thoroughly explored. If the number of hitherto unnoted tree diseases constantly being revealed by the pathologists of the staff is any indication of the situation with respect to forest insects, there will be plenty of work in the Allegheny territory for one or more forest entomologists.